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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

US ARMY TARDEC Robotics Overview

Bernard Theisen, Joint Center for Robotics

25 March 2010

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TARDEC Joint Center for Robotics

- S&T Support to the RS-JPO
- Develops and Fosters external Relationships
- Matures technology for Insertion into ATO programs
- Robotics Outreach
- RS JPO Collaboration Cell Lead
- Support to IGS Capability Cells
- Robotics Academic Programs (Including Curriculum Development)

Government Partnerships	Industry Partnerships	Academia Partnerships	Community Outreach
TRADOC	ABB BAE Delphi Ford General Dynamics General Motors Google iRobot JADI John Deere Lockheed Martin Oshkosh Polaris QinetiQ Quantum Signal Raytheon SoarTechnology Think-A-Move Toyota	Auburn University Carnegie Mellon Lawrence Technological University Massachusetts Institute of Technology Michigan State University Michigan Technological University Oakland University University of Detroit Mercy University of Michigan – Ann Arbor University of Michigan - Dearborn US Military Academy at West Point Virginia Tech Wayne State University	IGVC FIRST Robofest Robotics, Engineering and Technology Days TARDEC Robotics Quarterlies

Industry Focused Workshops

Motivation:

- Bring together Army/DOD robotics community, TRADOC ARCIC and ***local industry and academic leaders*** to discuss ***non-FCS*** uses of robotics **(Jan. 15, 2009)**

Unique Process:

- 'Mine' Army Universal Task List (AUTL) and TRADOC Warfighter Outcomes (**WFO**) for tasks that have the potential for benefiting from the use of robotics
- Group tasks into **engineering, security, medical, maintenance and logistics** categories and let smaller groups share ideas and processes across traditional boundaries and ***suggest unique, innovative robotic solutions***
- Use simple logic scheme to further assign a ***GREEN***, ***AMBER***, ***RED*** feasibility consensus to each robotics task and discuss the ratings with entire assembly

Results:

- Identified 5 ***MOSTLY FEASIBLE*** tasks in in **logistics, medical and security** and 35 ***POTENTIALLY FEASIBLE*** tasks in all 5 areas
- Stakeholders gain insight and begin new process that 'pushes **innovative technology**
- The **Robotics Innovation Workshop (RIW)** results will impact FY11 **WFO** and TRADOC Pamphlet 525-66 revision

Pushing Requirements to the User Based on Technology Development, Integration, Experimentation and Testing

Robotics Rodeo Summary

Goals of the Robotics Rodeo:

1. **Educate** key decision makers and **align** the robotics industry;
2. **Educate** Soldiers and developers;
3. **Observe** the current state of technologies to encourage the development of robotic systems to support operational needs.

Outcomes

- Momentum
- New business model
- Searchable database
- Referrals to PMs
- Feedback to vendors
- State of technology

Next

- Continued assistance in development of ONS technologies and procurement
- Conduct user assessment as needed
- Next Rodeo targeted for October 2010 focused on TRADOC approved capability gaps

III Corps ONS Overviews

Autonomous Detection Vehicle

- Autonomous route investigation and hazard marking
- Fundamentally a robotic appliqué kit on a vehicle to remove the Soldier from the vehicle for counter IED/route clearance.
- Funding exists for developmental phase (JIEDDO to NVL)

Convoy Logistics

- Kit-based, driver assist robotic follower system for current force tactical wheeled vehicles for increased situational awareness by the vehicle operator, giving increased opportunity for ambush and IED detection, and allowing for safer operation in limited visibility environments.
- Military User assessment at Fort Hood /Benning in 2010
- Funding exists for developmental phase and CONUS MUA

Submitted by III Corps

Validated by G-3/5/7 13 Nov 09

Similar capabilities identified in JCIDS process, FCS ORD and other ONS/JUONS

AR2B scheduled for 02 FEB 10

Varying levels of cost, schedule, performance risk and maturity

Robotic Wingman

- Large armed robotic platform assumes role as a member of squad / formation
- Leverage technologies under development by RDECOM under multiple ATO's
- Considerable development and technology maturation required for this capability

VOIED Defeat

- Capability for autonomous VOIED defeat
- Agnostic autonomous kit ready for any wheeled vehicle equipped with a suite of IED defeat payloads (rollers, cutters, rippers, blades, jammers, etc)

Persistent Stare

- A small robot with a sensor package that can navigate autonomously to a specified point and perform reconnaissance and surveillance enabling the robot to move through areas of anticipated enemy threat in order to provide real-time information to the operator within the carrier vehicle.

unclassified

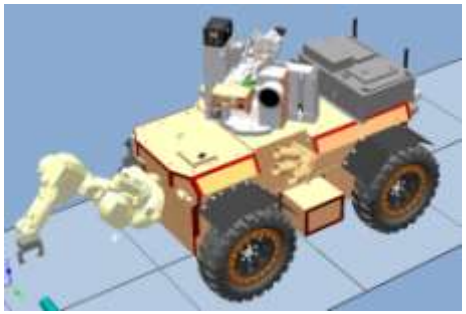
Transitioning Technology

Military Technologies:
- Sound Navigation and Ranging (Sonar) – Rear Backup Sensors
- Radio Detection And Ranging (Radar) – Adaptive Cruise Control
- Laser Detection and Ranging (LADAR) – Collision Detection
- Global Positioning System (GPS) - Navigation
- Machine Vision (MV) – Lane Departure
- Control Algorithm – Autonomous Navigation

Automotive Technologies:
- Controller–area network (CAN) – Vehicle Control
- Drive-by-wire (DbW) – Teleoperation
- Heating, Ventilating, and Air Conditioning (HVAC) – Signature Management
- Seat Belts and Air Bags – Increased Safety
- Humane Factors Engineering - MANPRINT
- Control Algorithm – Autonomous Navigation

Industrial Collaboration

- TARDEC integrated a Highly dexterous COTS industrial robots arm on UGV.
- Take advantage of an industry that has spent hundreds of millions of dollars in R&D to develop these technologies over the past 50 years.
- The arm is strong, faster and more reliable than fielded technology.
- Specially designed general purpose handling gripper.
- Advanced user interface for easy manipulation of robot arm with pre-defined routines for general tasks.
- Perform inspections, debris interrogation, hazardous material sample collector.
- Path forward for teleoperation, weight reduction and integrated controller approach.

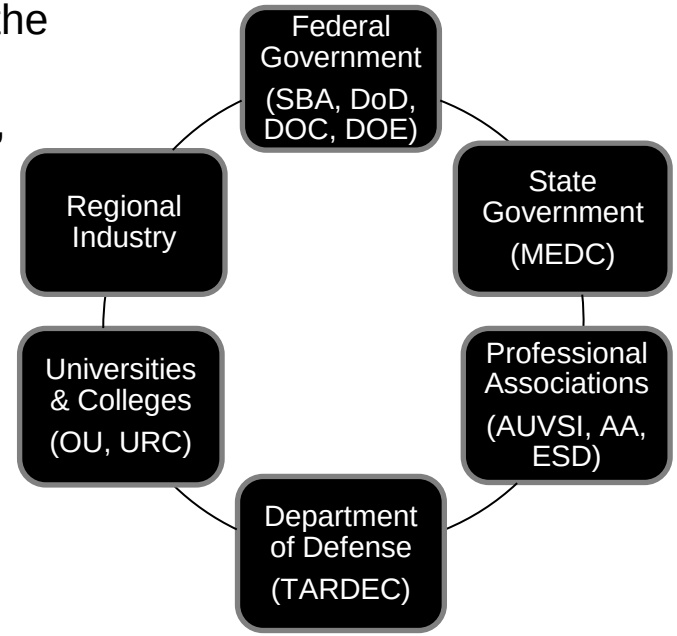


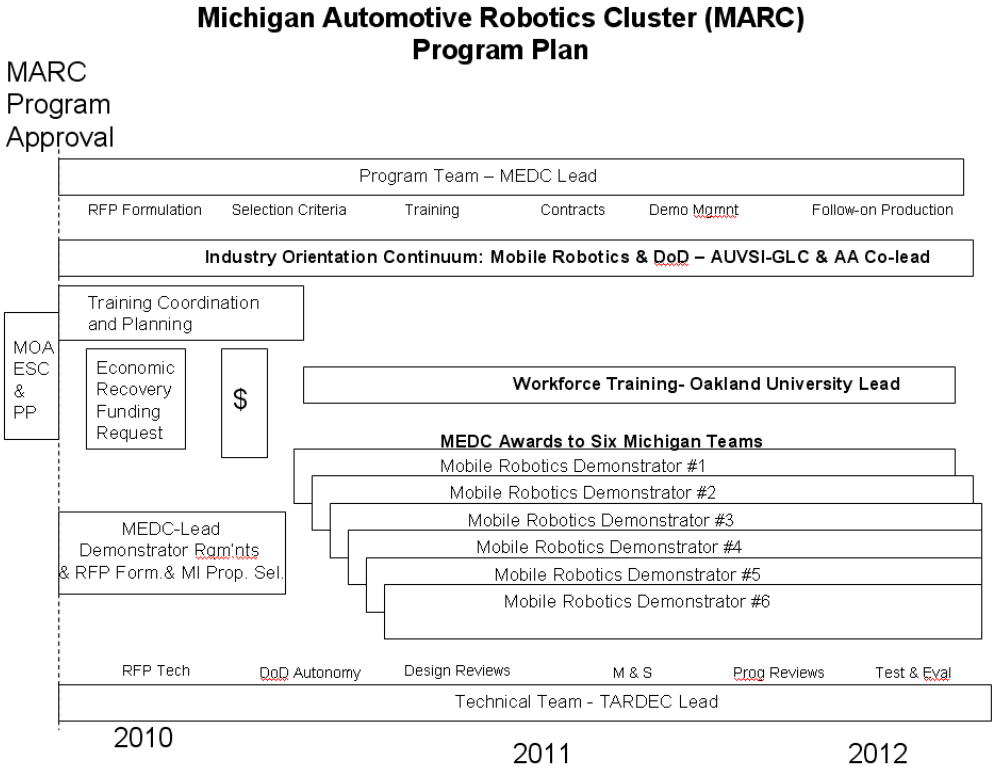
Michigan Automotive Robotics Cluster (MARC)

Purpose: Establish a technology cluster initiative focused on the development and manufacturing of robotic systems

Goals: Workforce Development, Small Business Participation, Automotive Industry Transition

- RFI's were received and reviewed
- Pilot projects to be awarded





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Cobra Gold 2010

- **The concept was derived from Marine feedback during Cobra Gold 2008 when the first prototype Warrior participated in the Technology Roadshow.**
- **First time a ground robotic platform preformed a live fire during an actual exercise with Warfighter's.**
- **TARDEC's role at the Combined Arms Live Fire Exercise (CALFEX) was to train the Marine's to use the Anti-Personnel Obstacle Breaching System (APOBS) munitions on the unmanned Warrior platform.**
- **The robotic APOBS was operated by Marine's and was a significant asset to the kick-off for the Closing Ceremony CALFEX, because it allowed the infiltration of the ground forces.**

Tanglefoot

- In response to a OEF ONS.
- Tangle Foot is a lost cost mechanical trip wire solution developed to be part of a toolkit for both Packbots and Talon UGVs. Both platforms Tangle Foot variants offer a tool-less quick connect/disconnect feature which is designed to maintain mission tempo.
- TARDEC robotics was responsible for the design and testing.
- Partners RS-JPO, PM IED Defeat, Keweenaw Research Center and JIEDDO.

Convoy Active Safety Technologies (CAST)

Purpose:

Provide low cost (sub 50K) convoy automation (Leader/Follower) capability for current force Army tactical vehicles -Support Warfighter requirement for convoy/resupply automation and active safety -Provide Robotics capability in CS/CSS community -Leverage road/vehicle image following, ultra wide band positioning, feducial tracking, low cost IMU and laser radar technologies.

Payoff:

Increase convoy operational tempo, reduce friendly vehicle collisions, decrease fatigue, increase operator situational awareness, workload management and threat response thru driving automation.

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Construction Engineering Robotic Kit (CERK)

Program Objectives:

Increase Soldier safety by removing them from the vehicle during dangers missions while improving the capabilities of the platform.

Program Goals:

– Provide low cost robotic capability for current force Army vehicles

– Support Warfighter requirement for improved safety

– Provide Robotics capability in CS/CSS community

– Leverage RDECOM Technologies

Advanced Platform Demonstrator (APD)

- **APD Program is developing, integrating and testing next-generation UGV mobility technologies.**
- **Key technologies include: Hybrid-electric drive systems, Advanced suspension technologies, Thermal management systems, Power management systems, UGV safety systems, and Lightweight hull technologies.**
- **It is a 6-wheel drive, skid-steer vehicle weighing 9.3 tons, series hybrid-electric vehicle, containing lithium-ion batteries that provide power to six in-hub electric drive motors. The APD also has an onboard diesel generator that can alternatively be used to provide power to the drive motors and/or charge the Li-ion batteries and is capable of speeds in excess of 50 mph.**
- **APD has logged more than 1300 kilometers, achieving a top speed of more than 50 mph and traversing a 60-percent longitudinal slope.**

Manned And Unmanned Vehicle (MAUV) SIL

Purpose:

Incorporate actual hardware both fielded and prototypes using simulation, stimulation and emulation to test concepts and validate capabilities.

- **Hardware In The Loop includes:**
  - **Vehicle Warfighter Machine Interface**
  - **Dismounted Controllers**
  - **FBCB2 and other ABCS**
  - **SoSCOE**
  - **Autonomous Control Algorithms**

Partners:

- **Robotic Systems Joint Project Office (RS-JPO)**
- **Cross Command Collaboration Effort (3CE)**
- **Natick Soldier Center – Infantry Warrior Simulation (IWARS)**
- **Night Vision Labs – Comprehensive Munitions and Sensor Server (CMS2)**
- **Modeling Architecture for Technology, Research and EXperimentation (MATREX)**

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Safe Operations (SafeOps)

- Increase Soldier Directly address risks associated with employing UGVs in dynamic environments
- Identify risk areas of operating UGVs around moving traffic, pedestrians & dismounted forces
- Integrating FCS representative technologies
- Dismounted forces safety
- Maintain lane among civilian traffic
- Develop the tools, techniques & autonomy to maximize mounted & dismounted control of ground and air unmanned systems and optimize Soldier-robot and robot-robot ground & air teams

Improved Mobility and Operational Performance through Autonomous Technologies (IMOPAT) ATO

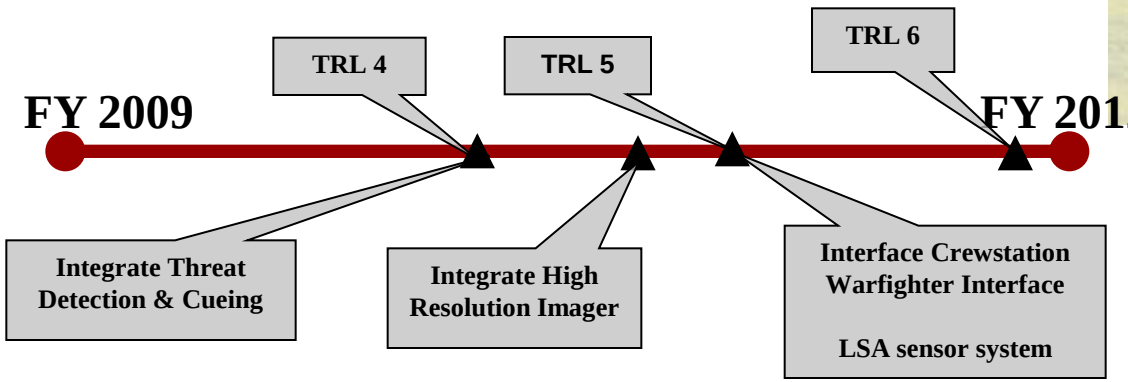
360/90 Day/Night
Near-field Sensor Coverage

Soldier Monitoring
& State Classification

Advanced
Crew Stations

Enhance, Integrate and Demonstrate 360/90 LSA/Assisted Mobility/Human Dimension to Maximize Indirect Vision 360/90 LSA and Mobility Capabilities (Secure Mobility)

- **Focus on closed-hatch operations, indirect vision**
- **360/90 degree local area awareness**
- **Improved mobility via non-LADAR and LADAR based solutions**
- **Improved assessment and integration of operator performance in real-time**
- **Increase situational awareness for all crew members**



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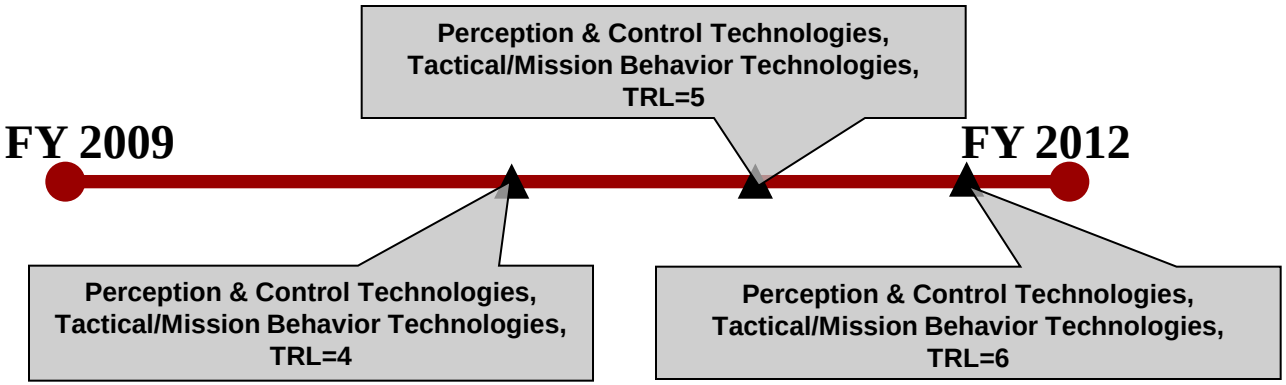
Safe Operations of Unmanned systems for Reconnaissance in Complex Environments (SOURCE) ATO

- Safer operations of UGVs in proximity to pedestrians and vehicles
- Increase in vehicle autonomy to enable less supervisory burden
- Increased UGV situational awareness
- Robust Soldier/robot and robot/robot teaming behaviors
- Robust UGV performance in all environments/conditions
- Simulation of platform, payload and algorithms in relevant operational environment



Robofest

- **Robofest challenges teams of students to design, build, and program autonomous robots to compete in the following competition categories, focusing on STEM (Science, Technology, Engineering, and Math) in Junior (grades 5–8) and Senior (grades 9–12) divisions:**
  - **Game Competition**
  - **Exhibition**
  - **RoboFashion and Dance Show**
  - **Vision-centered Mini Urban Challenge**
  - **Flutterbot Warehouse Firefighting**
  - **VEX Elevation**

Robotics, Engineering and Technology (RET) Week

- **RET Days focus on robotic systems given that this field is multidisciplinary in nature and demonstrates electrical, mechanical, and computer engineering aptitude.**

- **The intent of this activity is to allow students to gain insight into what can be done with technology based careers and why they should be focusing on math and science.**

- **This event supported Michigan's objective to become a technology based economy by sparking student's interest in technology based degrees and careers.**

  - **RET Day – MAY 07 – 600 students**
  - **RET Days – DEC 07 – 1,800 students**
  - **RET Week – DEC 08 – 3,600 students**
  - **RET Week – MAY 10 – 5,600 students**

Michigan For Inspiration and Recognition of Science and Technology (MI FIRST)

- **MI FIRST is a unique high school intellectual varsity sport designed to draw young people into the exciting and action-packed world of science and engineering. Students, engineering mentors, volunteers and participating universities help make this a great event.**

- **Michigan is the only state that runs its own internal FIRST competitions. This provides Michigan teams the opportunity to plan in over twice as many games for half the cost.**

- **Michigan has been very successful in their implementation of FIRST. Last year 4 out of the top 6 schools were from Michigan and a Michigan school has won the national championship 9 out 18 times (1999, 2001, 2002, 2003, 2004, 2005, 2006, 2008, 2009).**

Intelligent Ground Vehicle Competition (IGVC)

- **IGVC is cutting edge engineering education for university students built around a competition format that challenges students to design and build fully autonomous vehicles.**

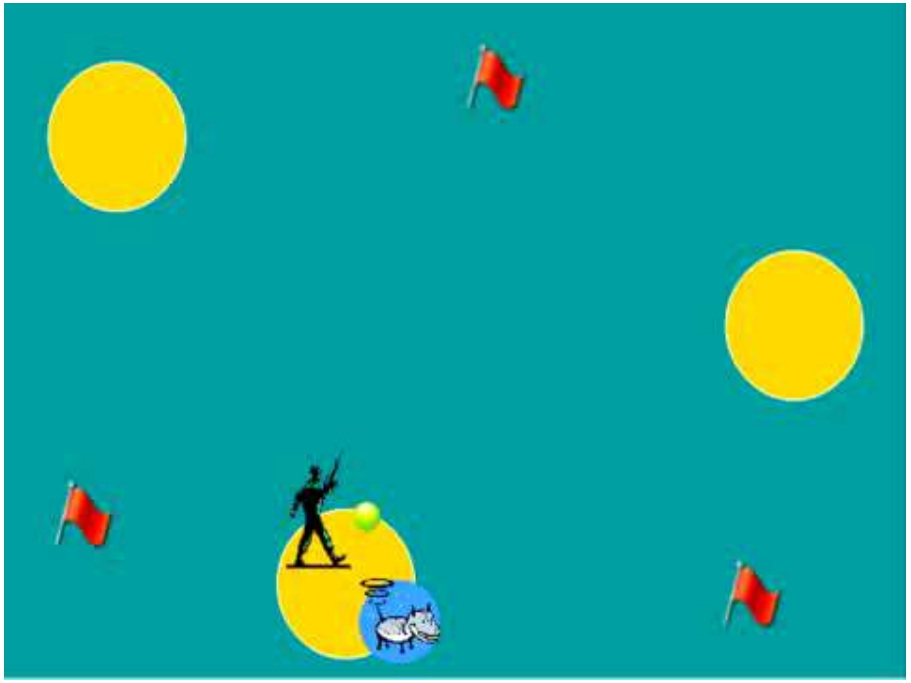
- **17 Competitions since 1993**
  - **Thousand of Students**
  - **375 Teams**
  - **72 University**
  - **4 Countries**

- **18TH IGVC**
  - **4 Challenges – Autonomous, Design, Navigation & JAUS**
  - **June 4-7, 2010**
  - **Oakland University, MI**
  - **Robfest Event**
  - **MI FIRST Event**

Collaborative Autonomous Navigation with Interactive Networked Engagement (CANINE)

CANINE intent on researching and developing advanced robotic collaborative behaviors through the teaming of industry and academia in a multi-year, multi-award, contract through the Robotics Technology Consortium where the advancement to the second year is contingent on performance at a completive down-select.

The desired behaviors are akin to those possessed by the military working dogs of years past. The focus is on the "Fetch" and "Surveillance" behaviors of these animals.



Year 1 - 6 Awards, $250k per recipient

Year 2 - 3 Awards, $500k per recipient

Multi Autonomous Ground-robotic International Challenge (MAGIC)

- **MAGIC is a Joint US/Australia Robotics Challenge**
  - **November 2010, in conjunction with Australian MOD Land Warfare Conference**
- **Emphasis on autonomy, inter-operability, user-to-robot ratio, data mapping, neutralizing mobile and static objects of interest, and heterogeneous robot teaming**
- **Down select to 5 teams competing**
  - **Oct 09: 32 proposals down selected to 12**
  - **Jun 10: final 5 teams selected based on site visit and demonstration**
- **Prizes 1st-$750K, 1st, 2nd-$250K & 3rd-$100K**
- **TARDEC is the U.S. Lead**

Australian
- MAGICIAN
- Strategic Engineering
- Numinance (Unfunded)
- University of New South Wales (Unfunded)

Canada
- Northern Hunters

Japan
- Chiba Team/Chiba University

Turkey
- Cappadocia

USA
- RASR
- Team Cornell
- Team Michigan
- Virginia Tech
- University of Pennsylvania

US ARMY RDECOM

Australian Government
Department of Defence
Defence Science and Technology Organisation

MAGIC 2010 DOWN UNDER
Multi Autonomous Ground-robotic International Challenge

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TARDEC Robotics Mission

Leverage the best available technology from industry, academia, and government to develop, integrate, and sustain high quality robotic capability in support of national security interests.

For more information, please contact us at:

DAMI_RoboticsRodeo@conus.army.mil

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TWVS ATD
GLASS CERAMIC
TRANSPARENT ARMOR
TARDEC
HERMIT
TARDEC

BACK UP

TARDEC Robotics

Mission

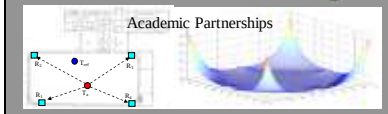
Integrate, Explore, and Develop Robotics, Network and Control Components with a Focus on Customer Driven Requirements to Provide Full System Solutions to the War Fighter

Technology Components









Integration

Demonstrators



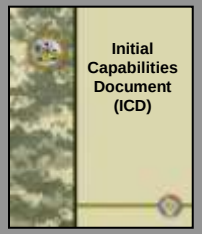
SME Defined Scenarios

Military Relevant Test & Experimentation



Tech Transfer

Transition and Requirements Development



Integration Technology Development Lessons Learned to Enable Early Technology Insertion

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TAGS-CX Robotic Platform Skunkworks

Purpose: Develop an integration testbed to evaluate and demonstrate modular plug & play mission payloads to demonstrate robotic capabilities

Payloads:
- **Picatinny Lightweight Remote Weapon Station**
- **Robotic decontamination**
- **Bobcat tools**
- **Robotic bridging**
- **Gun fire detection system**
- **Battlefield Extraction - Assist Robot (BEAR)**

Partners: JGRE, ARDEC, ARL, MANSCEN, TATRC

Following, Awareness, SafeOps, and Tracking through IGS (fastIGS)

Purpose:
Integrate, enhance, and demonstrate a 360˚ Spatial Awareness System using Ultra Wide Band for Dismounted Following and Mounted Autonomous Tactical Behaviors.

Payoff:
Drastically minimizes the amount of soldier intervention required to take unmanned systems along in dismounted operations.
Provides 360˚ Spatial Awareness for all assets in the system (manned and unmanned).

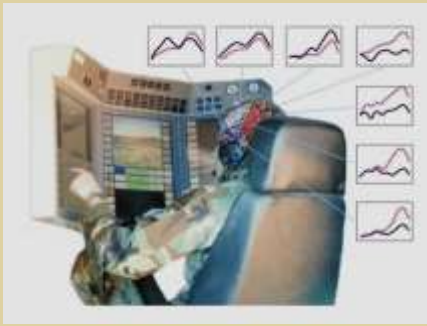
Crewstation Advancements

PAST
- Workload reduction
- Embedded crewstation

PRESENT
- Robotic control (mounted, dismounted)
- Driving aids (Soldier assist)
- Scalable, portable Interface

Dismounted Controller

FUTURE
- Soldier monitoring and task assist
- Intelligent agents
- 360 degree situational awareness



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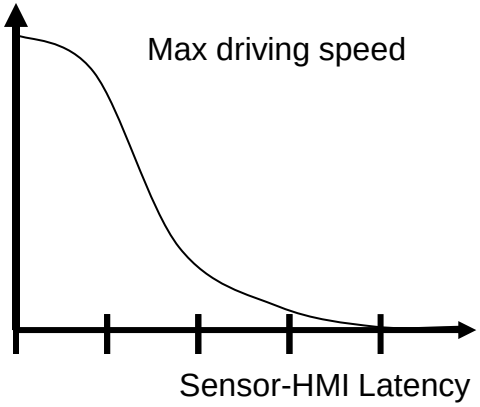
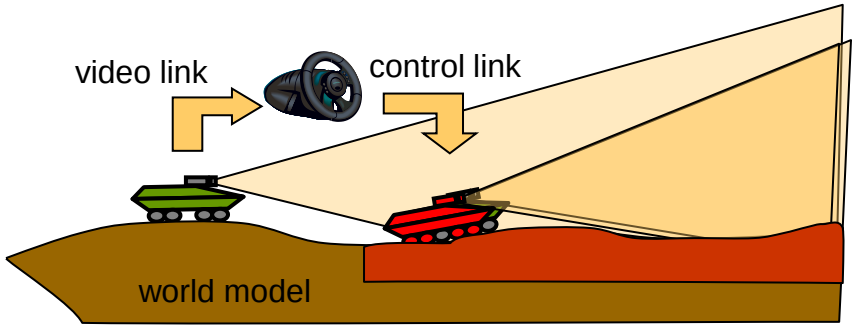
Soldier Awareness through Colorized Ranging (SACR)

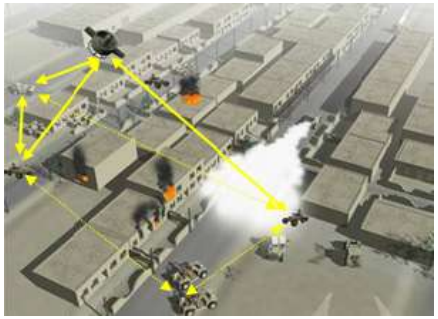




Near Autonomous Unmanned Systems (NAUS) ATO

Purpose:
Increase the level of autonomy of Unmanned Ground Vehicles (UGVs) toward operational consideration

Products:
- **Near-autonomous UGV operations in dynamic environments**
- **Near-autonomous dynamic UGV/MGV Tactical Formations**
- **UGV System Self Security through pedestrian Intent inference**



Robotics Collaboration (RC) ATO

Purpose: Develop the tools, techniques, & autonomy to maximize mounted and dismounted control of ground and air unmanned systems and optimize Soldier-robot and robot-robot ground and air teams

Scalable Interface:

– Increased scalability, portability and tailorability of Soldier Machine Interface—reduces training burden

– Control multiple unmanned system– one device can support unique robots from different vendors

Driving Aids:

– Enables Soldiers to take actions of a semi-auto vehicle while staying in obstacle avoidance

– Increased mission OPTEMPO, reduced intervention times

– Provides Situational Awareness of unmanned system

– Increased insight in unmanned system planning activities